FTD-MT-24-206-68

AD 681609

FOREIGN TECHNOLOGY DIVISION

PULSE FREQUENCY DISCRIMINATOR

by

Sh. M. Chabdarov

10

FTD-MT-24-206-68

EDITED MACHINE TRANSLATION

PULSE FREQUENCY DISCRIMINATOR

By: Sh. M. Chabdarov

UR/2529-66-000-092

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

FTD-MT-24-206-68 Date 6 Aug 1968

DATA HANDLING PAGE

01-ACCESSION NO.	98-DOCUMENT LOC	39-TOPIC TAGS
TT8501460		carrier frequency, circuit design, electronic signal, Fourier transform, frequency discriminator, pulse signal

09-TITLE

PULSE FREQUENCY DISCRIMINATOR

47-SUBJECT AREA

09

42-AUTHOR/CO-AUTHORS	10-DATE OF INFO
CHABDAROV, SH. M.	-----66

43-SOURCE	68-DOCUMENT NO. / 69-PROJECT NO.
KAZAN. AVIATSIONNYY INSTITUT. TRUDY (RUSSIAN)	FTD-MT-24-206-68 / 72302-82

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASN
UNCL, 0	NONE	UNCL

76-REEL/FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO. OF PAGES
1886 0631			UR	5

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
	65-AT7027351	94-00	Translation	NONE

STEP NO.	ACCESSION NO.
02-UR/2529/66/000/092/0062/0065	

ABSTRACT

A frequency discriminator designed to determine the carrier frequency or duty cycle of short bursts of radio signals is presented. It gives a discrimination characteristic with steep slope, and also reduces the coupling between the discrimination and transient characteristics of existing devices. It uses (for transforming the frequency change to a voltage change) the slope of the envelope of the frequency spectrum of amplitudes with rectangular frequency characteristics of the filter. The use of this method is desirable with input signals of short bursts. This pulse frequency discriminator is analyzed, using Fourier transforms, by studying the analogy between it and a pulse time discriminator. The output signal of the frequency discriminator is formed by subtracting the symmetrically tuned filter response at the input. In the time discriminator, the output is presented by the difference of the input and gating pulses with a symmetrical time shift. The output signals of the frequency discriminator. With symmetrical tuning, the orthogonal component of the filter can be neglected, and the output signal is considered proportional to the difference of the in-phase components. Thus, this discriminator is an application of synchronous detection. Orig. art. has: 16 formulas.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

PULSE FREQUENCY DISCRIMINATOR

Sh. M. Chabdarov

In radio electronics in a number of cases the problem of determination of carrier frequency of signals with wide spectrum arises. This problem is complicated when error in determination of carrier must be significantly less than the width of spectrum of analyzed signal (in particular, precision measurements of filler frequency of a short pulse).

In literature are given results of analytic and experimental investigation frequency discriminators in pulsed operation, showing the possibility of their use with short input signals [1-3]. A well-known detector-discriminator [4] also is intended for separation of short radio pulses by filler frequency, but in many cases devices with odd discrimination characteristics are preferable.

Discriminators examined in [1-3] are based on conversion of frequency shift to voltage change through slope of amplitude or phase of frequency characteristics of corresponding filter systems. The slope of discrimination characteristic is determined by the slope of the frequency curve of resonant filter systems, i.e., their Q factor. Therefore increasing the slope of the discrimination characteristic

---

Delivered at the Scientific and Technical Conference at Kazan Aviation Institute 27 March 1964.

of detectors decreased its width and leads to impairment of dynamic properties of the detectors.

As it is known [2], during operation of such discriminators in pulse mode, there is a limitation on the highest possible of filter systems, connected with duration of input signal.

However, another approach to designing the frequency discriminator for pulses is possible, i.e., the use for conversion of frequency shift to voltage change of the slope of the envelope of the frequency spectrum of amplitudes, with rectangular frequency curves of filter system. This will allow us to obtain a discrimination characteristic with steep slope, and also to weaken the so strong relationship between discrimination and transfer characteristics of all existing devices.

It is not difficult to see that use of the slope of the frequency curve of filter systems is efficient for input signals having an amplitude spectrum with sufficiently sharp drops, i.e., with continuous signals. Evenness of drop of envelope of spectrum is an undesirable factor, decreasing the slope of the discrimination characteristic. Use of slope of envelope of spectrum of amplitudes of input signal with rectangular filter characteristic is efficient for short input signals. An undesirable factor here is a nonrectangular filter characteristic.

During analysis of the examined pulse frequency discriminator, the method of simulation of properties and processes in the frequency discriminator by means of corresponding properties and processes in pulse-time discriminators can be useful. This possibility emanates from the analogy between processes taking place in these devices and is based on the properties of the Fourier transform. Actually, the output signal of the frequency discriminator is formed by means of subtraction of detected responses of filters symmetrically detuned relative to a certain frequency to input pulse. The output signal of the time discriminator is the difference in results of coincidence between input and gating pulses, symmetrically shifted relative to a certain instant.

As it is known, the structure of spectrum of the envelope of a radio signal with filler frequency ω_0 can be obtained from its spectrum by means of displacing the start of frequency reading to point ω_0. Therefore the output signal $U^{(ч)}_{вых}(t)$ of the frequency discriminator and its spectrum $S^{(ч)}_{вых}(\omega)$ can be recorded in the form

$$U^{(ч)}_{вых}(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} S^{(ч)}_{вх}(\Delta\omega)\left[\Phi_1(\Delta\omega) - \Phi_2(\Delta\omega)\right] e^{j\omega t} d\omega, \quad (1)$$

$$S^{(ч)}_{вых}(\omega) = \left[\Phi_1(\Delta\omega) - \Phi_2(\Delta\omega)\right] S^{(ч)}_{вх}(\Delta\omega), \quad (2)$$

where

$U^{(ч)}_{вх}(t)$ and $S^{(ч)}_{вх}(\Delta\omega)$ are input signal and its spectrum respectively;

$\Phi_i(\Delta\omega)$ – frequency characteristic of filters ($i = 1, 2$);

$\Delta\omega = \omega - \omega_0$ – "displaced" frequency, with beginning of reading at point ω_0.

For the time discriminator with video gating pulses it is possible to record accordingly:

$$U^{(в)}_{вых}(t) = \left[G_1(t) - G_2(t)\right] U^{(в)}_{вх}(t), \quad (3)$$

$$S^{(в)}_{вых}(\omega) = \int_{-\infty}^{\infty} U^{(в)}_{вх}(t)\left[G_1(t) - G_2(t)\right] e^{-j\omega t} dt. \quad (4)$$

When the following conditions are not

$$U^{(в)}_{вх}(t) \backsim S^{(ч)}_{вх}(\Delta\omega), \quad (5)$$

$$G_i(t) \backsim \Phi_i(\Delta\omega), \quad (6)$$

from relationships (1) and (4) it follows that

$$U^{(ч)}_{вых}(t) \backsim \frac{1}{2\pi} S^{(в)}_{вых}(-\omega). \quad (7)$$

and accordingly from (2) and (3) we have

$$S^{(ч)}_{вых}(\omega) \backsim U^{(в)}_{вых}(t). \quad (8)$$

Thus, when conditions (5) and (6) are met, the output signal of the frequency discriminator, with accuracy of cofactor $1/2\pi$, is the mirror image of the frequency spectrum of the output signal of the time discriminator (to shorter time correspond higher frequencies, and conversely), and the spectrum of the signal of the frequency

discriminator is the same for the output pulse of the time discriminators. This will allow us to apply the theory and methods of analysis of time discriminators to creation of methods of analysis and synthesis of pulse frequency discriminators, and also, possibly, to create a single theory for discriminators of short pulses.

The examined frequency discriminator possesses the following peculiarity. As it is known, the envelope of the transfer characteristic of the broad band filter with detuning contains cophasal P(t) and orthogonal Q(t) components [5]:

$$h(t) = P(t)\sin\omega_0 t + Q(t)\cos\omega_0 t. \tag{9}$$

Let us assume that $\omega_н$ and $\omega_в$ are lower and upper cutoff frequencies of the rectangular frequency curve of filter respectively, and that k is the slope of its phase characteristic. When

$$\omega_в - \omega_н < \omega_0 \tag{10}$$

for the case of $\omega_н < \omega_0 < \omega_в$ in [5] are obtained the following expressions for cophasal and orthogonal components:

$$P_1(t) = \frac{1}{2\pi}[\pi + Si(\omega_в - \omega_0)(t-k) + Si(\omega_0 - \omega_н)(t-k)], \tag{11}$$

$$Q_1(t) = \frac{1}{2\pi}[Ci(\omega_0 - \omega_н)(t-k) - Ci(\omega_в - \omega_0)(t-k)]. \tag{12}$$

For the case of $\omega_н < \omega_в < \omega_0$ it is possible, following the method of [5], to obtain analogous expressions:

$$P_2(t) = \frac{1}{2\pi}[-\pi + Si(\omega_в - \omega_0)(t-k) - Si(\omega_0 - \omega_н)(t-k)], \tag{13}$$

$$Q_2(t) = \frac{1}{2\pi}[Ci(\omega_0 - \omega_в)(t-k) - Ci(\omega_0 - \omega_н)(t-k)]. \tag{14}$$

For sufficiently large values of argument the value of the integral cosine is negligible; therefore if condition (10) is met, with symmetric detuning, from relationships (12) and (14) it follows that

$$Q_1(t) \approx Q_2(t). \tag{15}$$

Consequently, the output signal of the discriminator can be considered approximately to the difference between cophasal components

$$\Delta P(t) = P_1(t) - P_2(t) \approx$$
$$\approx 1 + \frac{1}{\pi}\left[Si\left[\omega_0 - \omega_1\right](t-k) + Si\left[\omega_2 - \omega_0\right](t-k)\right]. \quad (16)$$

Thus, information about carrier frequency of input is contained basically in cophasal components of filter response. Therefore in the pulse frequency discrimination it is possible to use synchronous detection.

Literature

1. Kaplanov M. R., Levin V. A. Avtomaticheskaya podstroyka chastoty [Automatic frequency control]. GEI, 1959, 1962.

2. Krivitskiy B. Kh., Avtomaticheskiye sistemy radiotekhnicheskikh ustroystv [Automatic systems radiotechnical devices]. GEI, 1962.

3. Grant E. F., "The response of frequensy discriminator to pulses". PIRE, April, 1949.

4. Nikitenko V. I., Detektor-diskriminator s vysokoy izbiratel'nost'yu [Detector discriminator with high selectivity]. IVUZ, Radiotekhnika, 1958, No. 5.

5. Dobrovol'skiy G. V., Peredacha impul'sov po kanalam svyazi [Transmission of pulses by communication channels]. Svyaz'izdat, 1960.

Submitted
5 July 1965